National Aeronautics and Space Administration

HST Imaging of Debris Disks

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Project Objective

Debris disks are formed around stars by the collision of comets, asteroids, and even planets. Without continual replenishment by such collisions, the disk would quickly disappear due to radiation pressure, stellar winds, etc. These dusty disks can have gaps, clearings, and spiral arms caused by unseen companions, perhaps planets. Using the *Hubble Space Telescope,* we are looking for disks with such planetary signatures.

Project Description

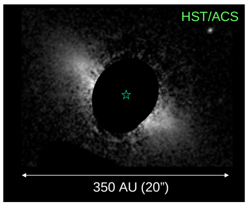
Potential debris disk candidates were identified by their infrared flux excesses relative to the expected stellar fluxes as measured with the *Spitzer* space telescope. We used the coronagraph in the Advanced Camera for Surveys on *HST* to obtain high-contrast images of these stars at visible wavelengths. The coronagraph suppresses the diffracted light from the telescope, making the faint disks easier to see. Residual instrumentally scattered light was removed by subtracting out images of stars with no known dust or by subtracting the image of the same star observed at a different orientation of the telescope. We are combining the infrared spectra energy distributions with three-dimensional models of the dust distribution to derive the structure and grain properties of the disks.

Project Results

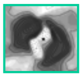
We have imaged for the first time three debris disks using *HST*. They are seen as starlight scattered by dust grains. The disks have one feature in common: apparent inner clearings. Such clearings may be signs of unseen low-mass companions (*i.e.* planets) near the stars that can sweep out the dust due to tidal interactions. One star, HD 10647, has a ~1 $M_{Jupiter}$ mass planet that was detected via radial velocity; that planet, however, is too close (~2 AU) to cause the clearing.

We will continue to use *HST* to detect debris disks as more *Spitzer* measurements become available to point us towards likely candidates.

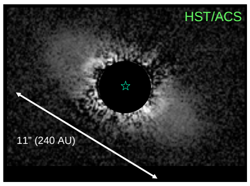
Star	Type	Dist (pc)	Age (Gyr)	Excess (L_{dust}/L_{star})
HD 10647	F9V	17	0.003-7	3×10^{-4}
HD 92945	K1V	22	0.1	8×10^{-4}
HD 207129	G0V	16	6	1×10^{-4}



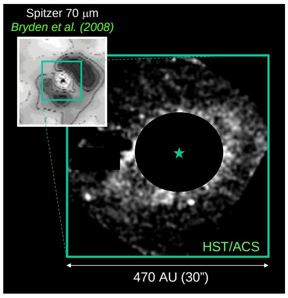
HD 10647: This F9V star at 17 pc distance has a ~1 M_{Jup} radial-velocity-detected planet at 2 AU. Its disk is a ring about 115 AU in radius seen nearly edge-on.



Spitzer/MIPS 70 mm image of the HD 10647 disk in thermal emission (same orientation, different spatial scale). Bryden et al. (in prep).

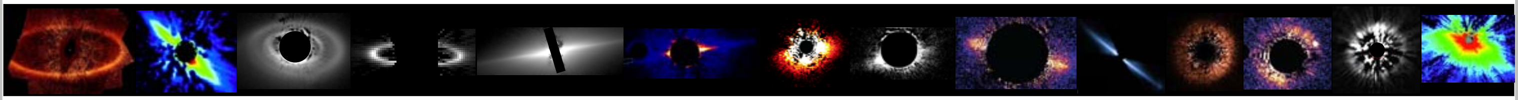


HD 92945: A K1V star at 22 pc, its ~120 AU radius disk has what appears to be a central clearing within 50 AU. The outer disk appears truncated. HD 92945 is a collaboration between the *HST*/ACS and *Spitzer*/MIPS science teams.



HD 207129: This old (~6 Gyr) G0V star at 16 pc has the faintest debris disk yet imaged (V=24 mag/arcsec²). It was only detectable using a special image processing method that combined images from two orientations of the telescope. The disk is resolved by *Spitzer* (inset). It appears as a ring with a radius of 135 AU.

Below: These are images of nearly all of the debris disks observed using the ACS and NICMOS coronagraphs on *HST*, both by the authors and other researchers. About 80% of all debris disks have been imaged only with *HST*, due to its advantages over ground-based telescopes for high contrast imaging.

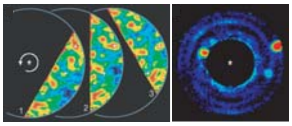


Fomalhaut HD 32297 HD 141569 HR 4796 Beta Pic HD 15115 HD 15745 HD 212917 HD 139664 AU Mic HD 107146 HD 53143 HD 181327 HD 61005

Benefits to NASA and JPL

These disks are important for understanding planetary formation, a key topic of study at NASA and JPL, especially in regards to projects such as the Space Interferometry Mission (SIM), the Terrestrial Planet Finder (TPF), and the proposed Eclipse projects. Low-density debris disks, like our solar system's own Zodiacal cloud, also present problems for these missions, as light from the disk can overwhelm that from any planets.

The experience gained from using coronagraphs on *HST* and the observation and image processing techniques involved can be directly applied to future exoplanet missions like TPF. For example, the same image processing software developed by the authors used to extract the image of the HD 207129 disk shown above was also used to extract simulated planets from actual JPL High Contrast Imaging Testbed data.



These images show simulated coronagraphic observations of extrasolar planets. Synthetic planet images were inserted into actual images from the HCIT testbed at different locations, replicating the effect of rolling the telescope between separate observations, as shown on the right (planets are at the crosses). The images were then processed using the same software used to extract the HD 207129 disk images from two *HST* observations taken at different orientations. The result is shown on the right. These figures are from Trauger & Traub (*Nature*, 446, 771; 2007).

Publications

Papers on the disks presented here will be published in 2008 by Krist et al. (HD 207129), Stapelfeldt et al. (HD 10647), and Golimowski et al. (HD 92945)..

Exoplanet Science and Technology Fair Von Karman Auditorium, JPL, 22 Feb 2008 Poster No. 32

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